Lighting for Woolen and Worsted Textile Mills

Prepared by the Joint I.E.S.-A.S.M.E. Committee on Lighting in the Textile Industry

Reprinted from the June 1949 issue of ILLUMINATING ENGINEERING.
Approved by the Council of the Illuminating Engineering Society
February 8, 1949.

Printed in the United States of America

AUGUST, 1949

Lighting for Woolen and Worsted Textile Mills

Prepared by the Joint I. E. S.-A. S. M. E. Committee on Lighting in the Textile Industry

Price 50 cents

Lighting for Woolen and Worsted Textile Mills

Prepared by the Joint I.E.S.-A.S.M.E. Committee on Lighting in the Textile Industry

PREFACE

The growth in knowledge of the benefits of properly applied lighting together with the recent important development in electric lamps and other "tools" of illumination, make possible an outstanding service to the seeing problems of industrial workers.

As part of its program to offer better solutions for all types of seeing problems, the Illuminating Engineering Society has formed a number of investigating committees. Each of these groups surveys the particular seeing tasks in the industry under study in order to recommend the quantity and quality of the lighting required for every important operation. The work of each committee is then summarized and published for use by lighting engineers and those who plan the work in industry.

Each committee includes not only lighting specialists but also men from the industry under study. The work of all of these committees is coordinated and reviewed by a Committee on Lighting Study Projects in Industry.

The method of investigation will vary according to needs and according to available technical personnel, time, and funds. In some cases the procedure will include a study and survey of seeing tasks and of lighting practice in large and small plants; to this may be added experimental installations providing several quantities of light and qualities of lighting which will be tried and appraised. Where practicable the foregoing will be supplemented by detailed studies of visibility and brightness patterns on location or in laboratory rooms. Much weight is given to practical considerations provided by the "user" representatives.

Not all of the above procedures are possible in all cases. Effort is being made continually to encourage thorough and scientific investigation and to provide better fundamental criteria. It is the intent that reports of these investigations shall clearly describe the scope and methods of study employed and which underlie the recommendations of quantities of light and of qualities and methods of lighting.

Herewith is presented a report of investigation of "Lighting for Woolen and Worsted Textile Mills."

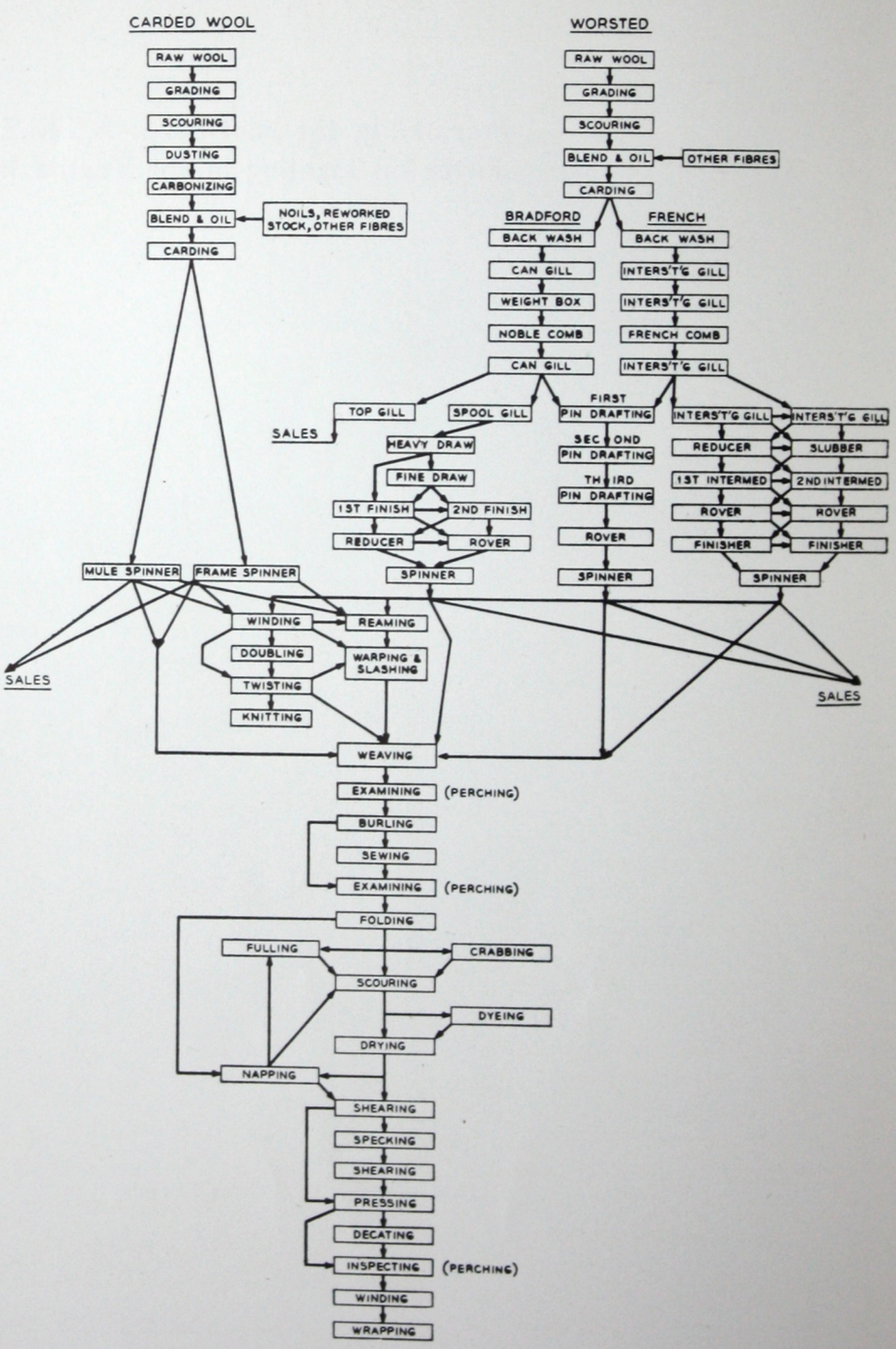


Figure 1. Flow chart for woolen and worsted cloth manufacture.

Figure 2. Wool is sorted out by an expert sorter, skilled in hand and eye, to divide the fleece into many grades according to its length, strength, and degree of fineness.—Courtesy of *Industrial Bulletin*, New York State Department of Labor.

Committee on Lighting Study Projects in Industry

J. R. Chambers
C. E. Egeler
A. W. Larson
Paul Manchester
H. L. Miller
G. G. Rae
M. N. Waterman, *Chairman*

FOREWORD

The Woolen and Worsted Textile Section of the Joint I.E.S. - A.S.M.E. Subcommittee on Textile Mill Lighting has been conducting studies to determine the quantity of illumination and the type of system and its arrangement most desirable and practical for woolen and worsted operations.

Surveys have been made in 17 New England woolen and worsted mills so that a cross-section of problems, operating methods, data and opinion could be obtained on which to base conclusions. The Bachmann-Uxbridge Worsted Corporation Mills, located in various parts of New England and in the South, have served as a laboratory for the activities of this committee. Many types and arrangements of lighting have been compared in these mills and the opinions of textile workers, management, and lighting engineers carefully noted. These data have been correlated with considerations of flexibility, installation, maintenance, and production records in determining the recommendations for woolen and worsted textile lighting as contained in this report.

The activities of this committee are still continuing and will do so until detailed illustrations of lighting practices for all important operations of this industry have been submitted in the form of data sheets. Data sheets have already been prepared on such operations as carding, spinning, weaving and perching. Later additional data will be submitted in similar useful form.

Control, restriction, or scarcity of materials in the years 1942 to 1946 prevented much needed improvement in textile lighting. Today with textile requirements at or close to an all-time peak, and with raw materials and labor at costly levels, modern well-planned lighting is essential to the maintenance of profitable textile operating standards.

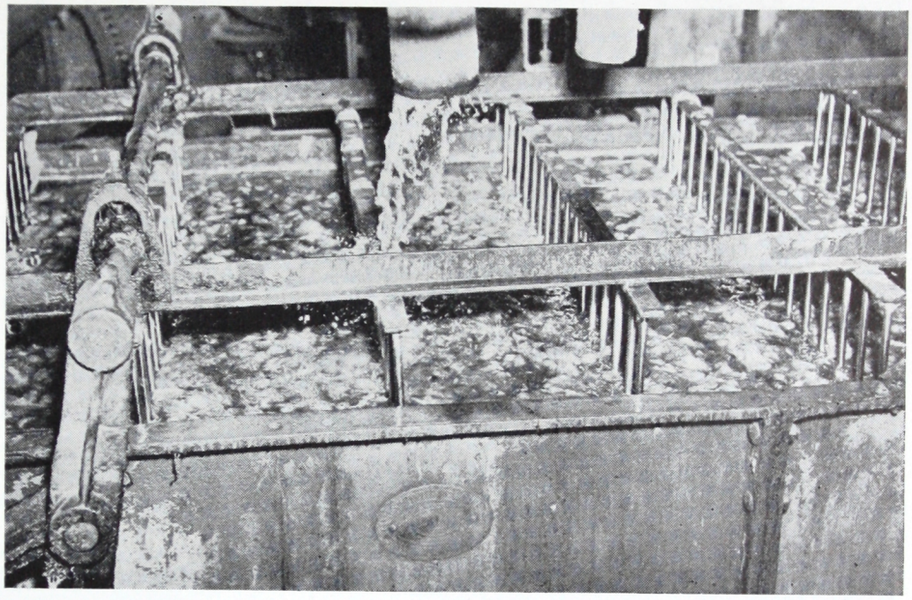


Figure 3. A wool scouring machine which washes the raw stock in a solution of soap and soda.

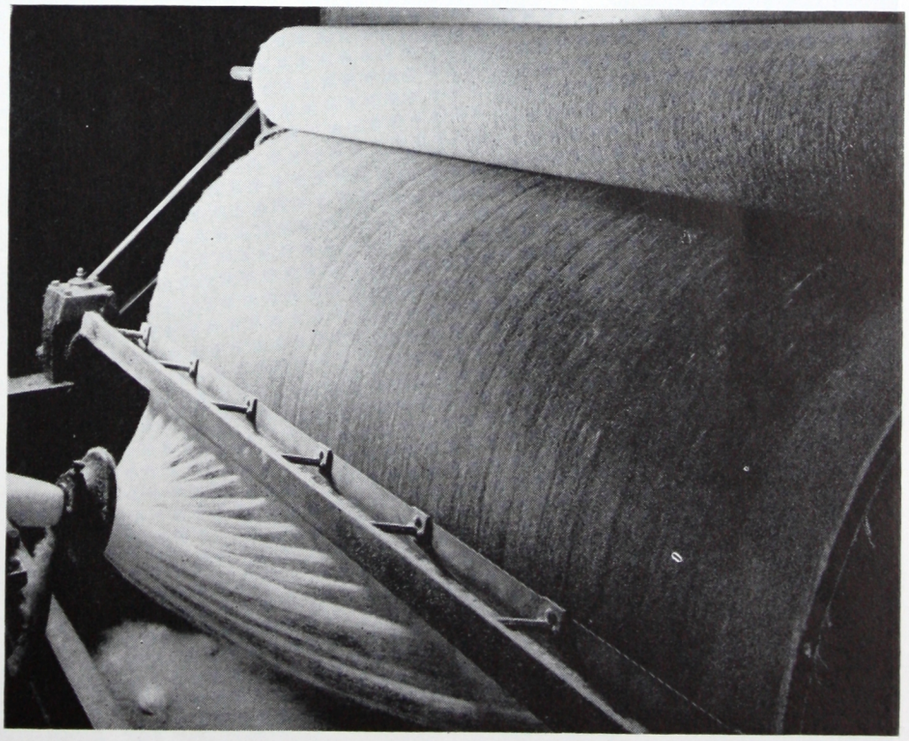


Figure 4. Blended wool fibres are carded to remove snarls and obtain a smooth, even blanket of yarn. The yarn is then twisted into roving in this worsted mill.—Courtesy of *Textile World*.

The committee realizes that operating gains from good lighting involve far more than merely increasing the level of illumination and properly locating equipment. Employee reaction to various lighting methods often modifies the best laid plans of the lighting engineer and this factor has received appreciable consideration in the recommendations of this report. For instance, the type and color of lamps, the type and size of lighting unit, as well as its location and mounting were often influenced by employee desires as long as satisfaction of such desires was possible without unreasonable sacrifice of lighting quality.

Joint I.E.S. - A.S.M.E Subcommittee on Lighting for Woolen and Worsted Textile Mills

Walter L. Kelley, *Chairman*
Walter P. Rayner
James M. Shute
Fred J. Vorlander
J. Edwin Watkins
Carl E. Rydman, Chairman, A.S.M.E. Lighting Committee

1. Scope and Purpose

This report comprises a series of recommendations for the lighting of woolen and worsted textile mill operations. The illumination levels based upon surveys and accumulated mill experience are presented for the various processes together with a detailed treatment of the lighting design for typical operations most frequently encountered as serious problems.

2. Definitions and Flow Diagram

For the purpose of this report the following definitions are used to clarify the processes through which woolen material must pass to become finished products. Fig. 1 illustrates the flow diagram.

2.1—Cloth Production

(a) *Opening*—Receiving and opening of bales of raw stock.

(b) *Grading*—Separating the raw stock according to grade. (See Fig. 2.)

(c) *Scouring* — Cleansing the raw wool of natural oils and other impurities. (See Fig. 3.)

(d) *Drying*—Removal of moisture.

(e) *Blending*—Mixing of raw materials by means of blowers or manual operation into a predetermined blend.

(f) *Picking*—Passage of the blended raw materials through picking ma-

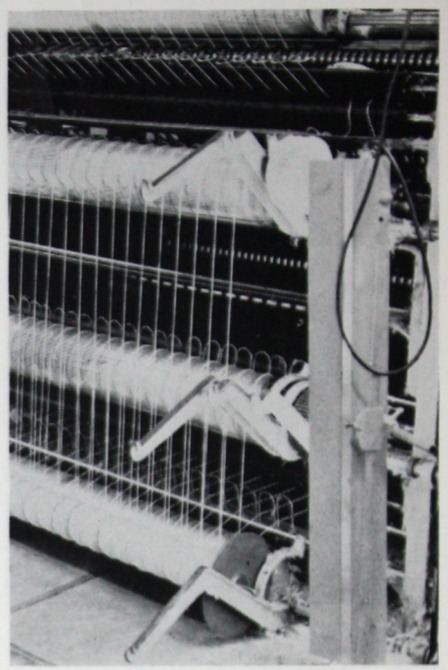


Figure 6. Supplementary lighting is necessary at the delivery end of woolen cards where the roping comes from the machine to the roping spools. The single 30-watt fluorescent lamp unit used here is supported in a vertical position and mounted on a portable base to provide flexibility.

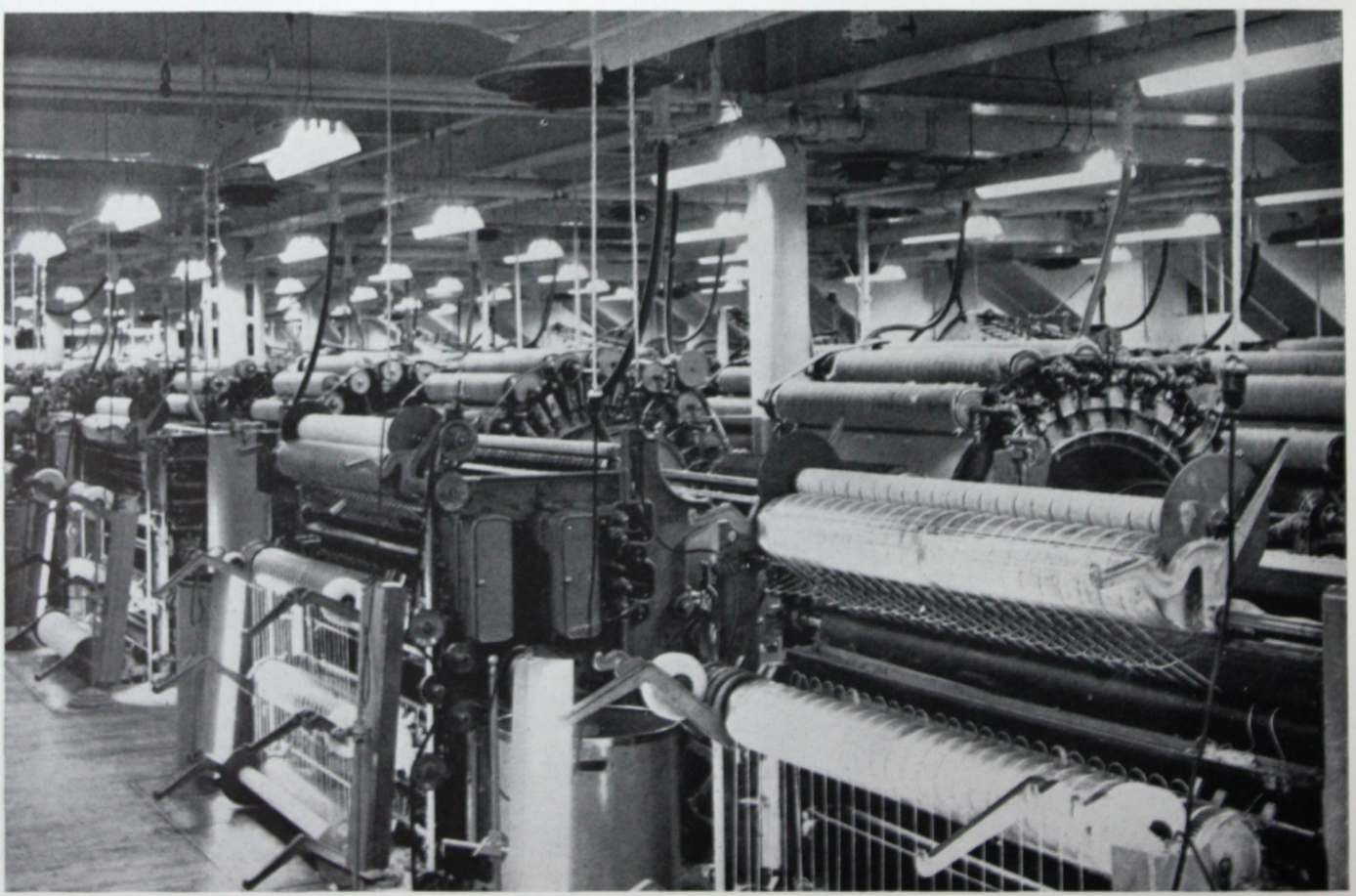


Figure 5. View of general lighting installation in card room. The 60-inch twin lamp fluorescent lighting reflectors produce an average of 45 footcandles on the horizontal surfaces of the machine and 35 footcandles on the vertical side surfaces.

chines to break up and further blend component stock.

(g) *Carding*—Passage of the blended materials through the carding machines for final blending and aligning of fibres. Material is delivered as either roving (worsted) or roping (woolen). (See Figs. 4, 5, and 6.)

(h) *Gilling* (worsted only)—Fibre combing, blending, and drawing by means of closely ranged steel pins dividing the wool fibres into parallel filaments.

(i) *Combing* (worsted only)—Fibres of carded wool fleece are aligned and the short and snarled fibres (noils) removed. Delivered as worsted top. (See Fig. 7.)

(j) *Recombing* (worsted only) — Repetition of combing operation.

(k) *Drawing* (worsted only) — First twisting and elongation of combed tops preparatory to spinning.

(l) *Spinning* — Final twisting and elongation of roving or roping to produce thread. (See Figs. 8, 9, 10, 11, and 12.)

(m) *Twisting*—The combining of two or more treads by twisting and elongation into multiple ply yarn.

(n) *Winding*—Repacking of yarn on spools, combs, bobbins, etc., preparatory to warping or weaving.

(o) *Warping* — Transferring of packaged warped yarn to loom beams.

(p) *Weaving* — Manufacturing of cloth from yarns. Accomplished on looms. (See Figs. 13, 14, and 15.)

2.2—Grey Goods Room

(a) *Burling* — Removal of knots, slubs, and foreign matter from woven fabric.

(b) *Sewing*—Repair of broken ends or imperfections. Replacement of broken or missing threads.

(c) *Folding* — The combining of pieces or cuts of cloth folded out in groups for finishing.

2.3—Wet Finishing

(a) *Fulling* — Treating of unfinished cloth with soap and alkali under weights and pressure to break and open up fabric to further interlock the fibres.

(b) *Scouring*—Washing of grey or fulled fabric to remove soap, alkali, dirt, and impurities.

(c) *Crabbing* — Preshrinking of cloth composed of wool and cotton.

(d) *Drying*—Removal of moisture.

(e) *Decating*—Process of setting the cloth by means of steaming in the finishing process.

2.4—Dry Finishing

(a) *Napping* — Raising of surface fibres for special finishes.

(b) *Shearing*—Cutting nap fibres to obtain uniform length (surface). (See Fig. 16.)

(c) *Conditioning*—Bringing fabric to predetermined moisture content.

(d) *Pressing*—Smoothing and making uniform the surface of cloth by the application of heat and pressure.

(e) *Inspecting* (perching)—Final inspection to determine imperfections. (See Fig 17.)

(f) *Folding*—Final packaging of cloth.

TABLE I

Lighting Levels at the Work—Current Recommended Practice

Process	*Footcandles Maintained in Service*		*Preferred Arrangement of Lighting Units*
	General Lighting	*Specific Lighting (General plus Local)*	
Opening	15		
Grading	25	100	Over tables.
Blending	15		
Picking	15		
Carding	35	Add an internal unit	
Combing	35		
Recombing	35		
Gilling	35		
Drawing (white)	25		Mount units parallel to frame. Minimum height 8′.
Drawing (Colored)	50		,,
Spinning (Frame) (white)	25		,,
,, ,, (colored)	50		,,
Spinning (Mule) (white)	20		Mount units either way. Minimum height 8′.
,, ,, (colored)	40		,,
Twisting (white)	25		Mount units parallel to frame.
,, (colored)	50		,,
Winding (white)	20		,,
,, (colored)	40		,,
Warping (white)	20	75 at reed	
,, (colored)	40	,, ,, ,,	
Weaving (white)	40		Mount units perpendicular to alley.
,, (colored)	80		,,
Grey Goods Room			
Burling	40	75	
Sewing	40	150	
Folding	40		
Wet Finishing			
Fulling	25		Units mounted to direct light into kettle.
Scouring	25		,,
Crabbing	25		
Drying	25		
Dyeing	25	50	Vapor-tight lighting units in kettle.
Dry Finishing			
Napping	40		
Shearing	40	75	
Conditioning	40		
Pressing	40		
Inspecting (Perching)	40	300	A 4′ x 4′ bank of fluorescent lighting units.
Folding	40		

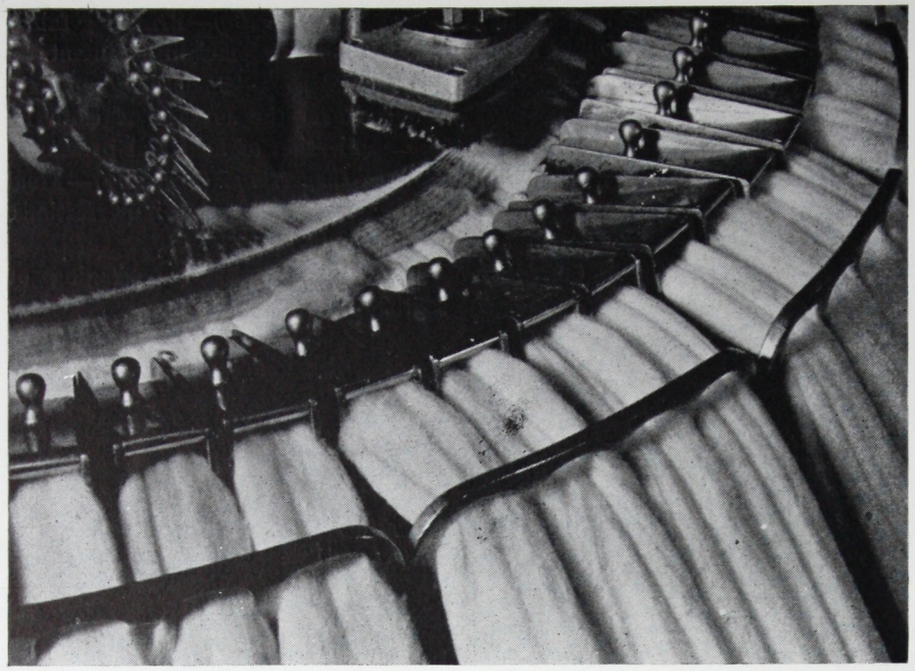


Figure 7. After carding the worsted roving is combed to remove short and snarled fibres. —Courtesy of *Industrial Bulletin*, New York State Department of Labor.

3. Illumination Recommendations

3.1—Quantity of Illumination

(a) The lighting levels in Table I are practicable values based on the visual requirements of the processes or operations involved. Higher levels may be helpful, especially in the case of dark materials and where fine detail is to be seen.

(b) The levels of illumination in Table I should be maintained in service on the work. In locations where the plane of the seeing task is not definite, the illumination is usually measured in a horizontal plane 30 inches above the floor. To assure a maintained level of lighting the initial value in footcandles must be greater by a percentage sufficient to compensate for the depreciation expected.

(c) In most cases general lighting will suffice, especially when the luminaires are positioned in accordance with the woolen machinery layout. Some operations require additional localized illumination. The illumination requirements from the general lighting, the general plus local, and the preferred arrangement of linear light source equipment are shown in Table I. Where positioning is indicated, the use of linear light sources is desirable to assure diffusion and to preserve good visibility through the reduction of shadows.

3.2—Environment — Pleasant, colorful surroundings make workers, especially women, more cheerful and contented, while color used in accordance with the principles of visual perception is a valuable contribution in seeing the task. General recommendations[4] are made as follows:

(a) Colors for general use should be fairly light and are best applied in plain over-all fashion.

(b) Pleasant colors should always be selected and where definite hues, such as green or blue are desired very light greyed tones should be used.

(c) Large areas of strong colors, such as bright red, yellow or green, should be avoided.

(d) While the ceiling should be near white so that the maximum light will be reflected, walls should not be white, as they then become brighter than the work task, and consequently uncomfortable. Reflectances of 50 to 60 per cent are recommended.

(e) Machines should be fairly light in color to reflect more light and to reduce strong contrasts for ease of vision. Reflectances of 25 to 50 per cent are recommended.

(f) Backgrounds to work tasks should be of a carefully chosen color and brightness to contrast with the task.

(g) Contrast obtained by hues of somewhat similar brightness is more efficient and restful than contrast in brightness alone.

(h) The upper surfaces of lighting units should be painted the same color as the ceiling to relieve contrast with ceiling and make them less conspicuous.

4. Lighting Design for Specific Processes

4.1—General Design

4.1.1 — *Introduction* — Previous studies[1,2,3,4] have indicated the desirability of reducing shadows and

Figure 8. The bobbin carrier or jack of the spinning mule moves to and from the stationary frame which supports the spools of roving or roping. When the bobbin carrier is at its most distant spot from the frame, all threads must be visible to the operator who moves about the machines repairing broken threads.—Courtesy of Crompton Parkinson Ltd., Manchester, England.

diffusing light into the many parts of the machinery in order to enhance the visibility of the details of the processes. The practical and economical availability of linear light sources has contributed greatly to the accomplishment of the objective. Fluorescent lighting is now readily adaptable to many of the lighting requirements of the woolen and worsted industry. Electric filament or mercury vapor lighting is useful in many locations where the diffusion of a linear source is not required.

4.1.2 — *Mounting Height* — Where fluorescent general lighting is employed, the units using 40-watt lamps should be mounted not less than 8 feet above the floor. General fluorescent lighting units using 85-watt fluorescent lamps should be mounted not less than 11 feet above the floor. The desired lighting level is governed by the spacing. Mounting heights compatible with suitable uniformity of illumination are recommended for concentrated light sources.

4.1.3—*Shielding*—To reduce the light toward the eye of the worker (glare), the mounting height specified above should be provided, and as much shielding as possible in harmony with efficient light output is recommended. This is especially true for concentrated light sources or where large expanses of linear light sources are exposed.

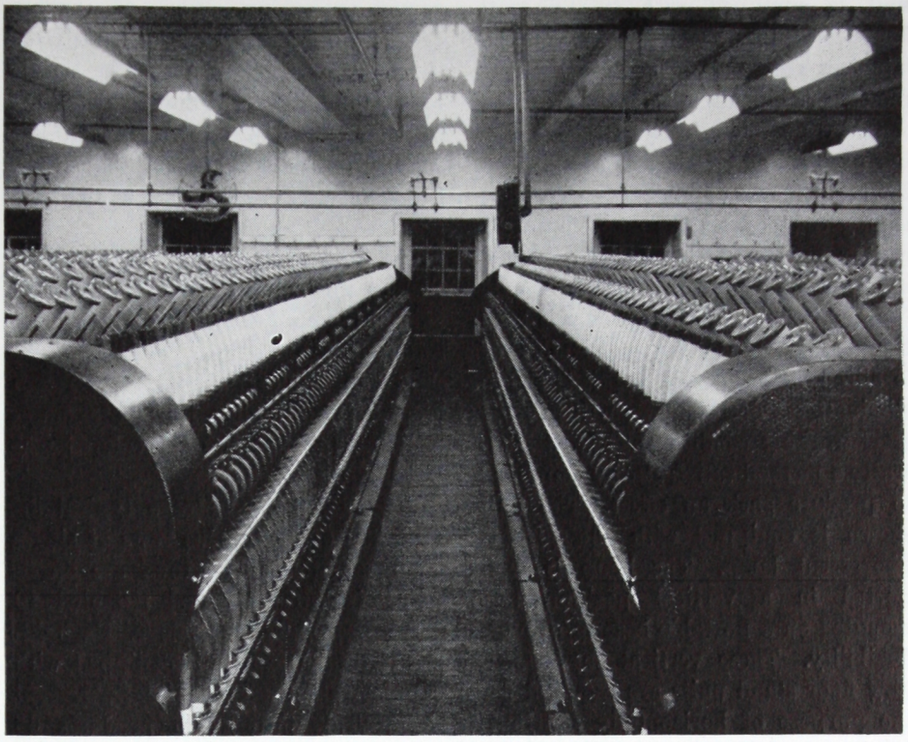


Figure 10. Ring spinners are illuminated in this plant by 85-watt 3500K fluorescent lamps in twin lamp reflectors. The maintained lighting level 30 inches above the floor is 50 footcandles.

4.2—Opening and Grading—When the raw wool arrives at the mill, it must be separated according to grade. This includes careful consideration of length, strength, degree of fineness, and color. (See Fig. 2.) In the room where this operation occurs tables or benches are usually placed near the walls leaving the center free for the bales of wool and baskets. The illumination over these tables should be constant in color and approximate average daylight conditions. To fulfill this fluorescent lighting of 6500K is recommended. General illumination will suffice for other areas in the room.

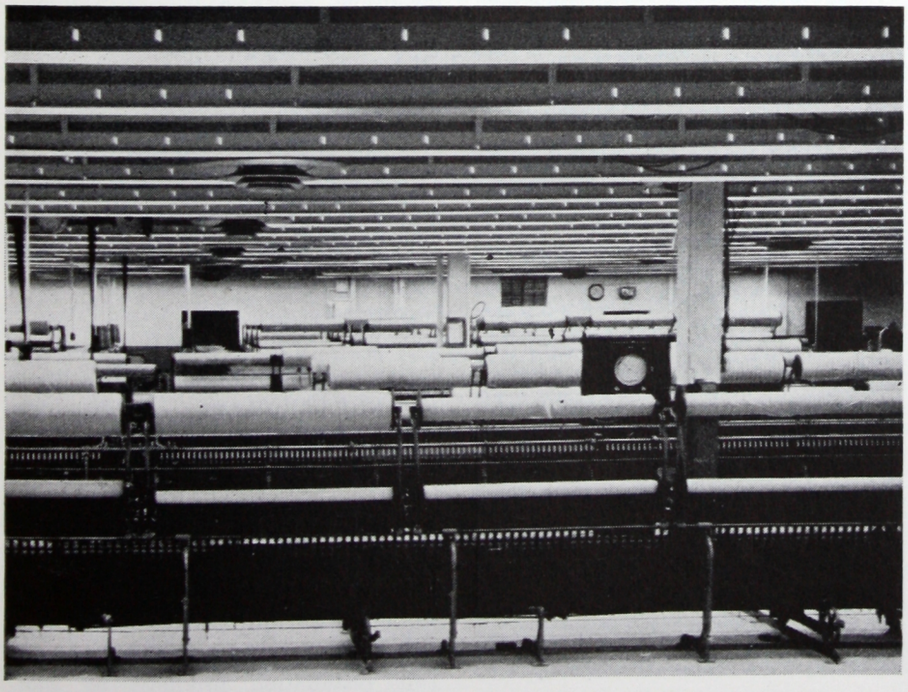


Figure 9. Continuous rows of 48-inch single lamp reflectors equipped with 40-watt 3500K white fluorescent lamps provide a 35 footcandle illumination level at these mule spinners.

4.3—Carding

(a) In this operation the woolen or worsted fibres delivered to the cards from preparatory processing are further blended and the fibres aligned. The operator keeps the laps of fibres feeding unbroken through rollers equipped with continuous wire combs as shown in Fig. 4. For this operation, general lighting of 35 footcandles is recommended as minimum. This same lighting equipment when properly located provides sufficient illumination for the card fixer who requires light at the sides of the machines for cleaning, adjusting, and repairing the machines.

(b) Fig. 5 illustrates a general lighting installation of twin lamp fluorescent lighting reflectors which produces an average of 45 footcandles on the horizontal surfaces of the machine and 35 footcandles on the vertical side surfaces. This installation consists of 60-inch reflectors spaced on 9-foot x 11-foot centers and mounted 11 feet 6 inches above the floor. Each

unit is equipped with two 85-watt 3500K white fluorescent lamps. The luminaires are mounted at 90 degrees to the axis of the aisles beside the cards.

(c) On woolen cards, a difficult seeing problem exists at the rub apron at the take-off end of the cards where the roping comes from the machine to the roping spools. General lighting will not satisfactorily produce adequate illumination for this task. It has been found that 45 to 75 footcandles of localized lighting so applied as to eliminate serious shadows will provide good working conditions. Fig. 6 illustrates a method satisfactorily employed to produce such an effect. The unit shown is equipped with one 30-watt fluorescent lamp. The lamp is supported in a vertical position and mounted on a portable base to provide flexibility. These vertical supplementary floor stand units are required for the purpose of horizontally distributing increased illumination at the delivery end of the rub apron. Such supplementary lighting is not considered necessary for worsted cards.

4.4—Spinning

4.4.1—*Spinning Mules*

(a) This operation involves the final twisting and elongation of roving or roping to produce thread as shown in Fig. 8. The bobbin carrier or jack moves to and from the stationary frame which supports the spools of roving or roping. When the bobbin carrier is at its most distant spot from the frame, all threads must be visible to the operator who moves about the machines repairing broken threads. The working plane is 36 inches high at the threads and up to 42 inches at the back rolls.

(b) General lighting is the best solution to this lighting problem. Illumination requirements depend upon the color of the material involved. As shown in Table I, these values range from 20 footcandles for white material to 40 footcandles for colored materials.

(c) Fig. 9 illustrates a typical installation of continuous rows of single lamp reflectors. The rows are on 6-foot 6-inch centers and mounted 10 feet 6 inches above the floor. Each 48-inch reflector section is equipped with one 40-watt 3500K white fluorescent lamp. This installation produces 45 footcandles initially and has a maintained value of 35 footcandles when cleaned of lint once each week. When single lamp units are installed, adjacent lamps should be equipped with twin lamp high power factor ballasts in order to minimize the stroboscopic effect. When twin lamp reflectors are used, the luminaire spacing shown in Fig. 9 should be modified. In general, to provide 25 footcandles average maintained illumination, one twin lamp 48-inch industrial reflector with 3500K white lamps should be provided for each 70 square feet of area involved. It appears to make little difference whether the rows of lamps run parallel to the mule frame or at 90 degrees to the frame.

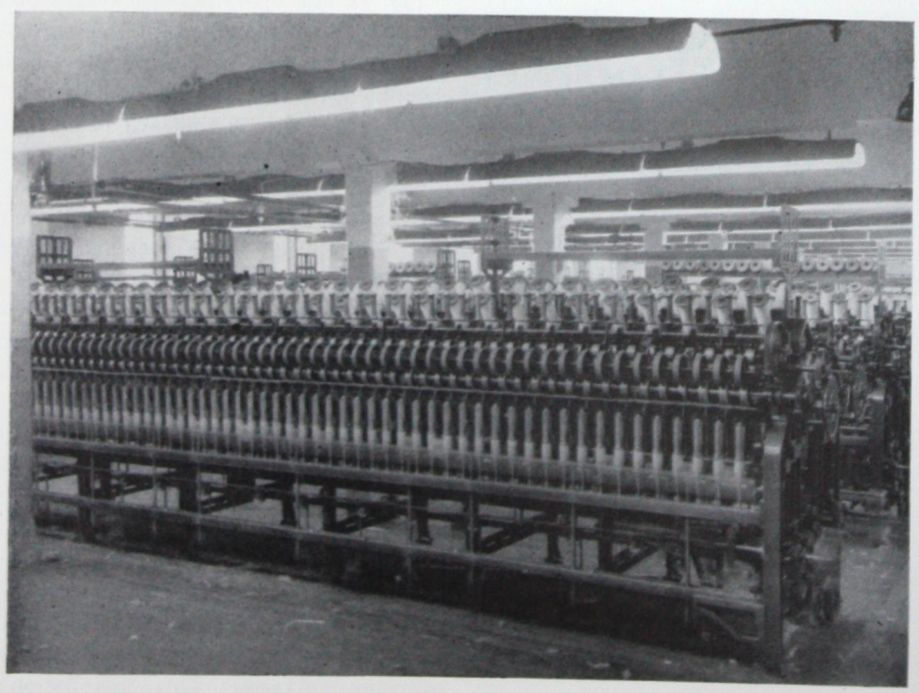


Figure 11. Cap spinners illuminated by open end, twin lamp reflectors mounted in continuous rows on 8-foot centers 8 feet above the floor. This installation provides 60 footcandles at the bar and 50 footcandles at the spindles.

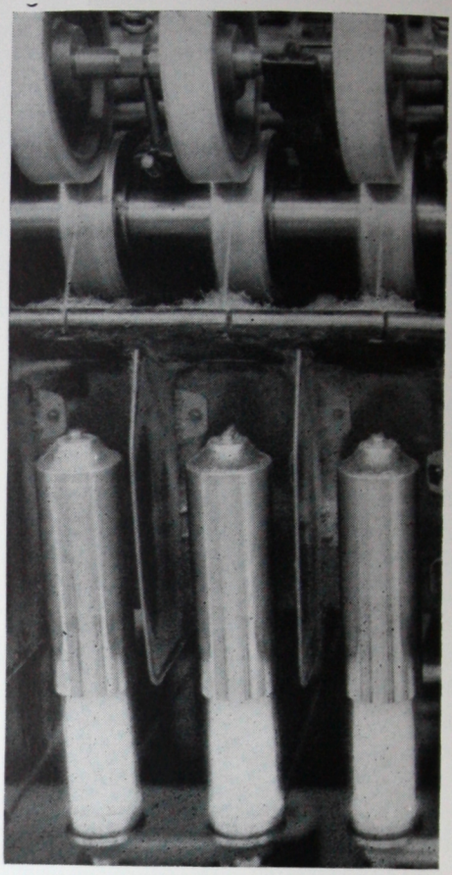


Figure 12. Closeup showing how the lighting installation shown in Fig. 11 eliminates shadows of the spindle barriers on the spindles.

4.4.2—*Spinning Frames*

(a) Spinning frames may be divided into two classifications: ring spinners and cap spinners. Fig. 10 illustrates one solution to the problem of lighting a ring spinner. This installation uses twin lamp reflectors and 85-watt 3500K white fluorescent lamps. These lighting units are mounted 11 feet 9 inches high with their long axis parallel to the aisle and are spaced 9 feet apart in rows 8 feet apart. The maintained lighting level is 50 footcandles on the horizontal plane 30 inches above the floor.

(b) Fig. 11 illustrates the lighting of cap spinners. Open end twin lamp 48-inch reflectors are mounted in continuous rows with the rows spaced on 8-foot centers and mounted 8 feet high. This installation produces 60 footcandles on a horizontal plane at the bar and 50 footcandles at the spindles where the seeing tasks are most impor-

Figure 13. Drawing-in, the first step in weaving. Threads from the warping beam are drawn through the heddles which control, when placed in the loom, the lifting or lowering of the warp threads in order to produce the weave desired.—Courtesy of *Industrial Bulletin*, New York State Department of Labor.

tant. A closeup view, Fig. 12, illustrates how this type of lighting eliminates shadows of the spindle barriers on the spindles, an important factor in lighting these machines.

4.5 — Weaving — This is one of the most critical tasks in textile operation and one where good illumination is most profitable since this is the basic production department of the mill. (See Figs. 13 and 14.) The lighting equipment must be arranged to minimize shadows. This can best be accomplished by installing rows of fluorescent luminaires perpendicular to the axis of the weave alley. Arrangements similar to those shown in Fig. 15 will enable the weaver to inspect the finished cloth as it is woven, detect broken threads, and repair them. They also provide satisfactory quantity and distribution of illumination for inserting the loom beam and for cleaning and maintaining the loom in good working order. Lighting requirements vary depending upon the color of the product; 40 footcandles is an average value for white cloth and 80 footcandles the requirement for colored cloth. In general, it has been found that when lighting levels of 80 footcandles were obtained by the use of

TABLE II

Effect of Lighting on Production Efficiency

Wool Yarn Spinning—1¼ Run
Lighting changed from 11.0 ft-c incandescent to 42 ft-c fluorescent.
Production improved 9.6%—Bad yarn decreased 11.5%.

Wool Yarn Spinning—2½ Run
Lighting changed from 11.0 ft-c incandescent to 42 ft-c fluorescent.
Production improved 8.4%—Bad yarn decreased 12.6%.

Weaving Automobile Cloth Type 1—worsted warp, wool filling

Weaving efficiency	Incandescent lighting,	14-17 ft-c	81.0%
,,	,, Fluorescent ,,	32 ft-c	84.0%

Decreased mending cost 22%.

Weaving Automobile Cloth Type 2—worsted warp, wool filling

Weaving efficiency	Incandescent lighting,	14-17 ft-c	83.0%
,,	,, Fluorescent ,,	32 ft-c	87.7%

Decreased mending cost 25%.

Weaving Wool Dress Goods—wool warp, wool filling

Weaving efficiency	Fluorescent lighting,	32 ft-c	66.5%
,,	,, ,,	52 ft-c	69.0%

Decreased mending cost 12.5%.

Weaving Wool Filled Cotton Warp Men's Wear

Weaving efficiency	Fluorescent lighting	32 ft-c	78.3%
,,	,, ,,	52 ft-c	81.5%

Decreased mending cost 14.0%.

Weaving Automobile Cloth—worsted warp, wool filling

Weaving efficiency	Fluorescent lighting	52 ft-c	82.4%
,,	,, ,,	70 ft-c	83.8%

Decreased mending cost 9.0%.

Average results from weaving tests show improvements progressively as follows:

	14-17 ft-c	32 ft-c	52 ft-c	70 ft-c
Lighting	Incandescent	Fluorescent	Fluorescent	Fluorescent
Weaving Efficiency	100%	104.6%	108.7%	110.5%
Mending Costs	100%	76.5%	66.4%	60.4%

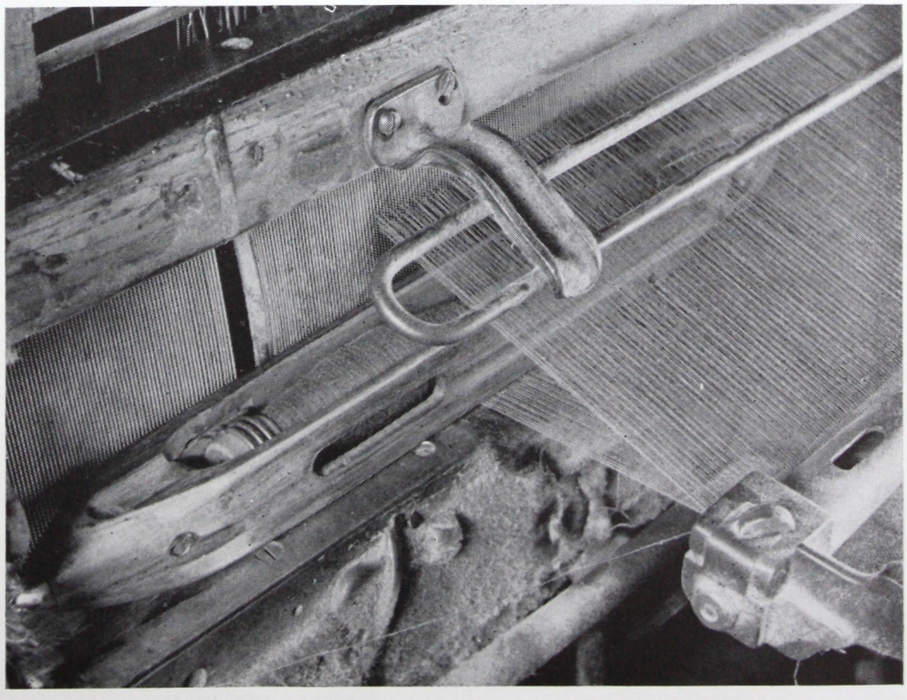
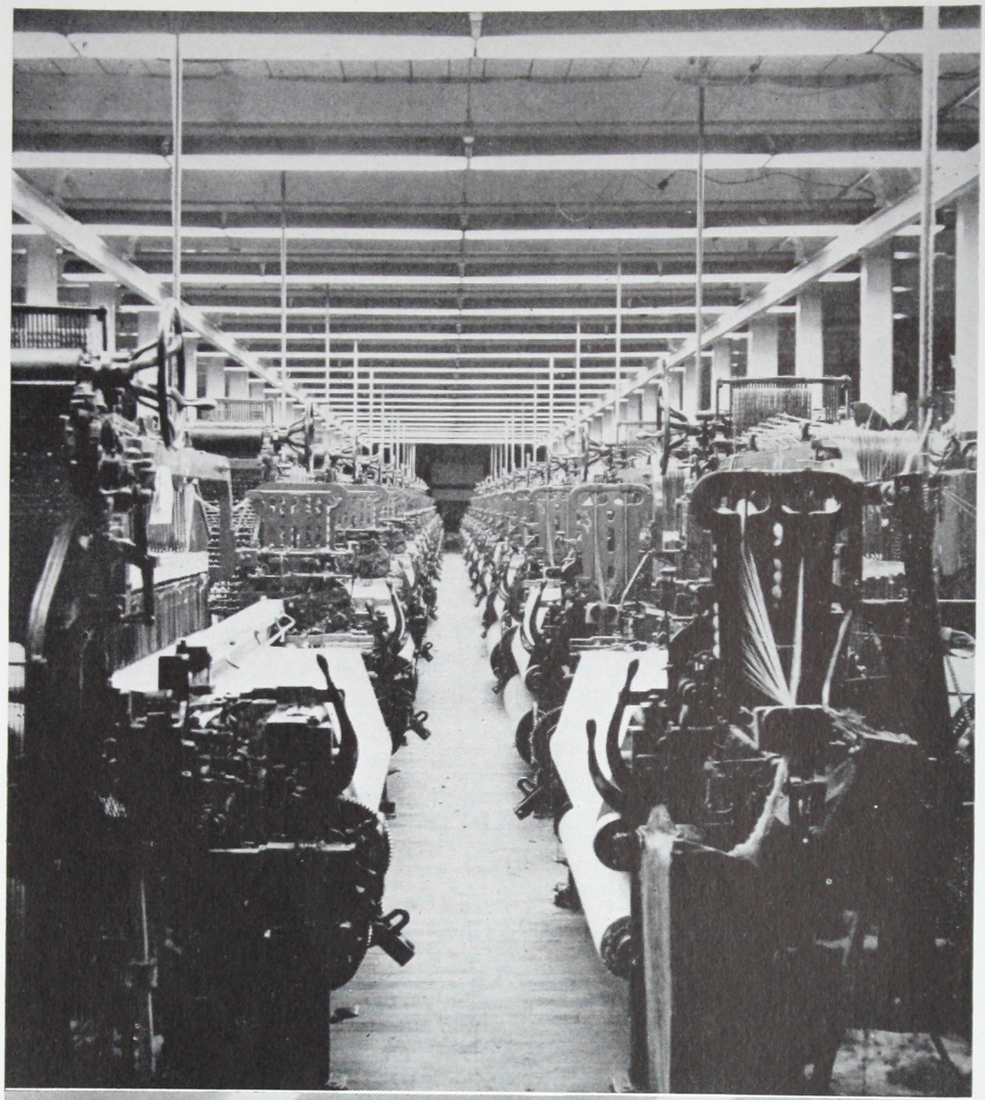


Figure 14. In the loom above, the warp is the long threads that move up and down as controlled by the heddles. The filling thread passes back and forth through the warp threads as the shuttle is propelled from side to side.—Courtesy of *Industrial Bulletin*, New York State Department of Labor.



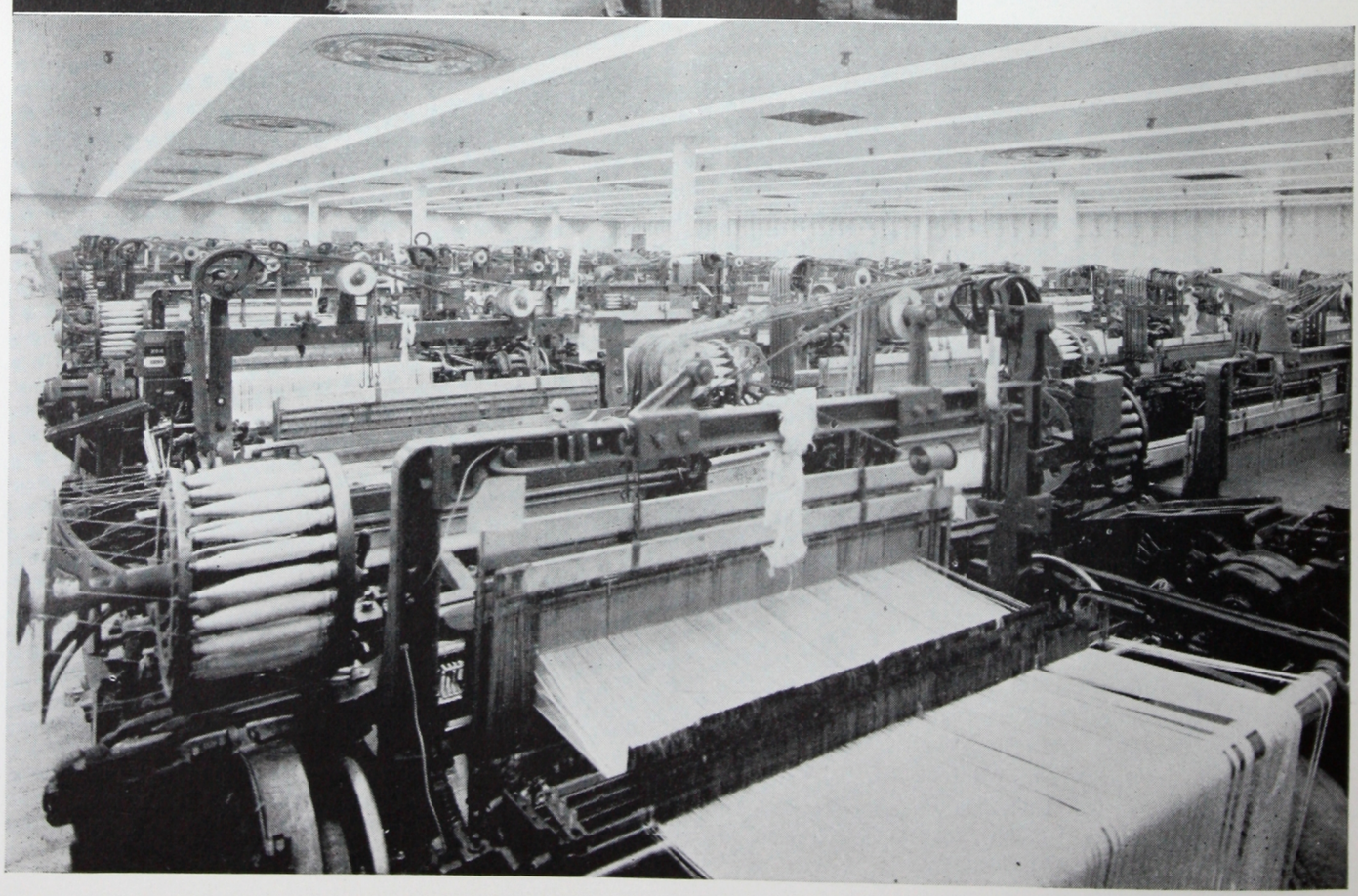
unlouvered, porcelain-enameled, industrial fluorescent lighting reflectors, surface brightness of the fixtures and lamps approach values where a glare condition exists. In view of this, it is recommended that where higher levels of illumination are required for mounting heights of 10 feet or less reflectors should be equipped with shielding in the form of well-designed louvers having a shielding angle of not less than 45 degrees.

4.6—Perching

(a) This operation involves the final examination of finished worsted and woolen textiles. Proper quality and color of light is very important here.

(b) Each perch hangs vertically from the framework and the perch board (often adjustable) is usually set at a 10-degree angle from the vertical toward the inspector. As the cloth is pulled over the board and stacked at the bottom, the ex-

Figure 15. Here, and on facing page are three examples of good lighting practice for looms.



aminer looks for imperfections of all kinds, i.e., wrong colors of yarn, off-shades, spots, shadiness of goods, and mistakes in pattern.

(c) This is a very severe visual task and requires direct illumination ranging from 300 to 400 footcandles of localized lighting plus 40 footcandles of general lighting. This can best be provided by a fluorescent lamp installation of the type shown in Fig. 17. This unit consists of five twin lamp or ten single lamp specular reflectors each equipped with a 40-watt daylight fluorescent lamp. The frame is mounted in a nearly vertical position and at such an angle and height facing the perch board that a line perpendicular to the face of the reflectors, midway between the ends of the tubes, strikes the perch board at the eye level of the examiner who stands facing the perch board with the light at his back. (See Fig. 17.)

(d) The framework of the perch should be of a neutral, light shade to minimize brightness ratios. Any existing windows in back of the examiner should be covered with an opaque paint to block out daylight so that variation of daylight intensity and color will not create interference. The daylight colors of lamps are chosen because most workers prefer this color at the high intensities used here. Due to the use of specular reflectors the apparent brightness of the assembly is low.

5. Results of Improving Textile Illumination

(a) Actual tests to prove the tangible advantages of improving the illumination of textile operations are very limited due to the many variables which are a basic part of the textile industry. Types of stock or types and styles of fabrics going through any one department change frequently in the modern woolen or worsted mill. Rarely are these factors constant sufficiently long for various qualities or quantities of illumination to be compared under similar working conditions since such tests require consid-

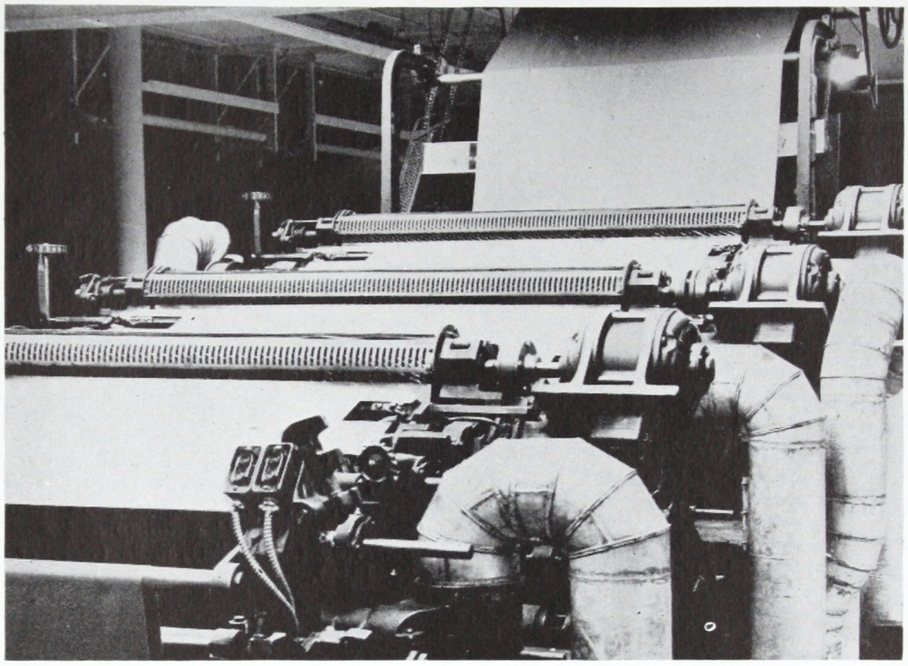


Figure 16. The final process on wool cloth is shearing, in which a fine, even finish is produced by shears which operate like hair clippers or a lawn-mower.

Figure 17. The finished cloth is inspected on perch boards. Supplementary lighting units containing ten 40-watt daylight fluorescent lamps in specular reflectors provide the 300 to 400 footcandles required for this seeing task.

erable time. Obviously, unless exactly the same materials and operations are involved, direct comparison of lighting systems cannot be made.

(b) During the period from 1941 to 1948 occasional tests of this nature were conducted in the mills of a large textile organization. In each test all labor, machines, materials, and processes were unchanged; the lighting was the only variable. The data presented in Table II show the effect of various lighting installations on production efficiency and spoilage for spinning and weaving.

6. References

1. "Report on Lighting in the Textile Industry — Grey Goods and Denim," *Transactions I.E.S.*, Vol. XXXII, No. 3, p. 247 (March, 1937).
2. "Lighting for Silk and Rayon Throwing and Wide Goods Weaving," *Transactions I.E.S.*, Vol. XXXIII, No. 1, p. 17 (January, 1938).
3. Holdsworth, T. C., Howell, J. W., and Jackson, J. H., "Lighting in the Woolen and Worsted Industry," *Transactions I.E.S.* (London), Vol. VII, No. 8 (September, 1942).
4. Duncan, A. F., "Lighting in the Textile Industry," *Building and Engineering* (Australia), p. 33 (October 24, 1944).